NON-PUBLIC?: N
ACCESSION #: 8808240244
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Diablo Canyon Unit 2 PAGE: 1 of 9

DOCKET NUMBER: 05000323

TITLE: Reactor Trip and Subsequent Safety Injection Following an Electrical Ground on a Connector to Reactor Coolant Pump 2-2 Due to Galling on the Threads of an Aluminum Stud
EVENT DATE: 07/17/88 LER #: 88-008-00 REPORT DATE: 08/16/88

OTHER FACILITIES INVOLVED:
FACILITY NAME: Diablo Canyon Unit 1 DOCKET #: 05000275

OPERATING MODE: 1 POWER LEVEL: 050

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTIONS
50.73(a)(2)(iv), Other Special Reports

LICENSEE CONTACT FOR THIS LER:
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TELEPHONE #: 805-595-7351

SUPPLEMENTAL REPORT EXPECTED: No

ABSTRACT: On July 17, 1988, at 0717 PDT, with Unit 2 in mode 1 (Power Operation), a manual reactor trip and a manual reactor coolant pump (RCP) 2-2 trip were initiated due to electrical faults indicated in RCP 2-2. The other three RCPs were tripped due to continued feeder ground alarms placing the unit on natural circulation at 0746 PDT. At 0746 PDT, start up transformer breaker OCB 212 opened, making startup power unavailable to either unit. Diesel Generators (DG) 1-3, 2-1, and 2-2 started and loaded onto their respective Unit 2 4 kV vital buses. In addition, the loss of startup power caused the autostart of Unit 1 DGs 1-1 and 1-2. At 0757, secondary system transients resulted in a steamline differential of pressure safety injection (SI). An Unusual Event (UE) was immediately declared in accordance with plant emergency procedures. At 0759 a pressurizer power operated relief valve lifted. At 0814 PDT, the UE was reported to the NRC in accordance with 10 CFR 50.72(a)(1)(i).

Galled aluminum threads resulted in an electrical connection which, with thermal and electrical cycling, deteriorated over 4 years and eventually produced enough heat to cause a ground fault. The connection was replaced,

the 12 kV system inspected, and RCP 2-2 returned to service.

This was the eleventh emergency core cooling system actuation cycle that resulted in a discharge of water into the reactor.

(End of Abstract)

I. Initial Conditions

Unit 2 was in Mode 1 (Power Operation) at 100 percent power prior to the event, but had ramped down to 50 percent power at the time of the manual reactor trip. Unit 1 was in Mode 1 at 30 percent power during this event.

II. Description of Event

A. Event

On July 17, 1988, while DCPP Unit 2 was at full power a series of events occurred which resulted in a loss of Unit 1 and Unit 2 12 kV startup power, a manual Unit 2 reactor trip, and a safety injection. These events started at 0602 PDT, when feeder ground alarms actuated on Reactor Coolant Pump (AB)(RCP) 2-2 and Circulating Water Pump (SG)(CWP) 2-1 on 12 kV Bus D (EA) and CWP 2-2 on 12 kV Bus E.

At 0603 PDT, a 12 kV Auxiliary Transformer ground overcurrent alarm was received and at 0610 PDT a report was received that the associated ground resistor bank was hot. The control room operator attempted to locate and isolate the ground by transferring the 12 kV Bus D to the startup transformer.

At 0636 PDT, a RCP 2-2 phase unbalance alarm was received. A connector (AB)(CON) at the motor terminals of RCP 2-2 was in the process of failing. From 0640 PDT to 0715 PDT the operators reduced power to 50 percent and tripped the feeder breaker (SG)(BKR) to CWP 2-1 in an attempt to isolate the ground. At 0715 PDT a fire at the Startup Transformer 2-1 Ground Resistor (EA) was reported to the Control Room Operators. At 0717 PDT the operators initiated a manual Reactor Trip and RCP 2-2 breaker was tripped. When the reactor was tripped, 12 kV Bus E was automatically transferred to the Startup Bus. At 0719 PDT RCP 2-4 was manually tripped. At 0733 PDT RCP 2-1 was manually tripped. At 0746 PDT, RCP 2-3 was manually tripped. Although

230 kV offsite source main breaker OCB 212 opened automatically at the same time that RCP 2-3 was manually tripped, the two events were not related. The opening of OCB 212 made startup power unavailable to either unit. Diesel generators (DGs) 1-3, 2-1, and 2-2 started and loaded onto their respective Unit 2 4 kV buses. In addition, the loss of startup power caused the autostart of Unit 1 DGs 1-1 and 1-2 and the trip of CWP 2-2.

The fire in the vicinity the startup transformer 2-1 grounding resistor bank was due to the burning of insulation on a cable which connected the 230/12 kV Startup transformer grounding transformer to the grounding resistor bank. A sheet of micarta type material had been inadvertently left on the resistor banks directing heat from the resistor banks to the cable which had been routed over the resistor banks. This fire caused a short to ground in the damaged cable. This grounded condition caused two

of the grounding transformer fuses to blow, breaking defective welds holding the fuse block to the fuse panel and causing the fuse block to move from its position in the fuse panel. The blown fuses left the 12 kV system ungrounded and the resulting voltage transients combined with the new position of the fuse block resulted in a phase to phase fault and the trip of offsite power breaker OCB 212.

At 0757 PDT, a safety injection occurred due to steam generator 2-3 high steam line pressure differential pressure resulting from secondary system transients. Since RCP 2-3 was the last RCP to be tripped, it's associated steam generator was the main heat sink. This resulted in SG 2-3 being cooled off more than the other steam generators which ultimately depressurized it to the differential pressure (SG) setpoint of 100 psid. This caused the eleventh emergency core cooling system actuation cycle that resulted in a discharge of water into the reactor. An Unusual Event (UE) was immediately declared in accordance with plant emergency procedures. At 0759 a pressurizer power operated relief valve (AB)(PORV) lifted and reseated. At 0814 PDT, the UE was reported to the NRC in accordance with 10 CFR 50.72(a)(1)(i).

At 1000 PDT, a natural circulation cooldown to RHR was initiated. Action Statement a. for Technical Specification 3.8.1.1 required that the plant be in cold shutdown within 30 hours

following the reactor trip unless offsite power was restored. Since the time required to restore offsite power could not be determined and the time to restore the main circulating water and reactor coolant pumps could not be determined, the cooldown to cold shutdown was initiated using natural circulation and the RHR system.

In addition the secondary system transients produced water hammers in the condensate and feedwater systems. Slow depressurization of the Condensate and feedwater systems caused flashing in the Feedwater Heater No's. 1 and 2 inlet and outlet and other connected piping. With no Condensate or Condensate Booster Pumps operating, depressurization occurred in lines connected to the condenser/hotwell.

While Unit 2 was without offsite power, compressed air system pressure temporarily fell below normal due to loss of power to some compressors.

B. Inoperable structures, components, or systems that contributed to the event:

None

C. Dates and approximate times for major occurrences.

1. On July 17, 1988, at 0602 PDT: Feeder ground alarms are received on RCP 2-2, CWP 2-1 and 2-2.

2. On July 17, 1988, at 0603 PDT: 12 kV S/U or auxiliary transformer ground OC alarm is received.

3. On July 17, 1988, at 0610 PDT: Control room receives report that auxiliary transformer 2-1 ground transformer resistor bank is very hot.

4. On July 17, 1988, at 0636 PDT: RCP 2-2 Phase Unbalance or DC Bus undervoltage alarm is received.

5. On July 17, 1988, at 0640 PDT: Plant load rampdown is

initiated at 10 MW/min.

6. On July 17, 1988, at 0703 PDT: Plant load rampdown rate is raised to 20 MW/min.

7. On July 17, 1988, at 0715 PDT: Unit at 50% power, CWP 2-1 is secured. Fire is reported in the S/U transformer grounding resistor bank.

8. On July 17, 1988, at 0717 PDT: Manual reactor trip is initiated.

9. On July 17, 1988, at 0717 PDT: RCP 2-2 is manually tripped.

10. On July 17, 1988, at 0717 PDT: All 12 kV and 4 kV busses automatically transferred to startup power.

11. On July 17, 1988, at 0719 PDT: RCP 2-4 is manually tripped.

12. On July 17, 1988, at 0733 PDT: RCP 2-1 is manually tripped.

13. On July 17, 1988, at 0746 PDT: RCP 2-3 is manually tripped. The reactor is now on natural circulation.

14. On July 17, 1988, at 0746 PDT: OCB 212 opens - loss of startup bus. DG 2-1, 2-2 and 1-3 started and loaded onto their respective Unit 2 autostarted but did not load onto the Unit 1 buses, since Unit 1 continued to operate and supply its auxiliary and vital buses.

15. On July 17, 1988, at 0757 PDT: Safety Injection on S/G 2-3 Steamline High differential pressure initiated. Since the 2-3 RCP was the last pump to be tripped, its associated S/G had been the main heat sink. This resulted in SG

2-3 being cooled off more than
the other S/Gs, which
ultimately depressurized it
to the differential pressure
setpoint of 100 psid.

Unusual Event is declared. 10
CFR 50.72(a)(1)(i)
notifications made.

16. On July 17, 1988, at 0759 PDT: PORV PCV-455C opens to relieve
RCS transient pressure and
reseats. Cause of high RCS
pressure is loss of normal
spray flow (all RCP's secured)
and auxiliary spray (Phase A
Isolation). This occurs
several times over the next
7 minutes.

17. On July 17, 1988, at 0807 PDT: SI terminated.

18. On July 17, 1988, at 0814 PDT: UE Reported to NRC.

19. On July 17, 1988, at 0824 PDT: Auxiliary Power is energized,
all 4 kV Busses are
transferred to auxiliary
power.

21. On July 17, 1988, at 1955 PDT: Entered Mode 4.

20. On July 17, 1988, at 1000 PDT: Natural circulation cooldown
to RHR is commenced.

22. On July 18, 1988, at 1401 PDT: Entered MODE 5, terminated
Unusual Event.

D. Other systems or secondary functions affected:

Waterhammers in the condensate and feedwater systems damaged a spring can hanger rod. The compressed air system pressure dropped below normal, but maintained acceptable pressures throughout the event. Some condenser tube plugs were blown out by the secondary system transients. PORV PCV-455C opens to relieve RCS transient pressure and reseats. Cause of high RCS pressure is loss of normal spray flow (all RCPs secured) and auxiliary spray (Phase

A Isolation) combined with the high ECCS injection

flow. PORV PCV-455C cycles open and reseats several times over the next 7 minutes.

E. Method of Discovery:

Operators were aware of a ground and ensuing incidents due to alarms in the control room.

F. Operator actions:

Upon receipt of the feeder ground alarms, a ramp down to 50 percent power was initiated. After reaching 50 percent power, the CWP on 12 kV bus D was tripped in an attempt to isolate the ground. When this failed, a manual reactor trip was initiated and the feeder breaker to RCP 2-2 was manually tripped. The other three RCPs were manually tripped due to the continued electrical system alarms being received on the S/U busses due to the damaged S/U transformer grounding cable. After manually tripping the other three RCPs, a natural circulation cooldown was initiated. After a SI and PORV actuation due to transients in the primary and secondary systems, the unit was stabilized in Mode 3 in accordance with plant emergency procedures.

G. Safety system responses:

1. The reactor trip breakers (JC)(BKR) opened.

2. The control rod drive mechanism (AA)(DRIV) allowed the control rods to drop into the reactor.

3. All ESF equipment started as designed in response to a safety injection signal.

4. Diesel generators (EK)(DG) 2-1, 2-2, and 1-3 started and loaded onto their respective 4 kV vital buses.

5. Diesel generators 1-2 and 1-1 started but, per design, did not load.

6. Auxiliary feedwater pumps (BA)(MO)(P) started per design.

7. Pressurizer power operated relief valve (PORV) PCV-455C cycles

open and reseats several times to relieve high RCS pressure.

III. Cause of Event

A. Immediate cause:

The event was caused by an inadequate electrical connection on RCP 2-2.

B. Root Cause

TEXT:
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PG&E conducted an extensive investigation of the potential causes of this event using a multidisciplinary Event Investigation Team (EIT). The EIT determined that the material condition of the connector in the motor terminal of reactor coolant pump (RCP) 2-2 was the root cause.

PG&E evaluated the following potential root causes:

1. Installation

The galling of the electrical connector on RCP 2-2 occurred during installation in 1984. The cause of the galling could not be determined.

2. Material degradation

The material condition of the electrical connector in the motor terminal of reactor coolant pump (RCP) 2-2 was determined to be the root cause of this event. Galling in the threads of the stud holding the connector resulted in a snug but not tight connection, but after thermal and power cycles for four years a high resistance connection resulted which heated sufficiently to breakdown the insulation surrounding the conductor, allowing an arcing path to ground. Investigation showed that the connector had been installed in accordance with manufacturer's instructions, however, before achieving a satisfactory electrical connection, galling in the threads of the stud holding the connector produced torque resistance matching that recommended to assure a good electrical connection.

3. Design

The design of the electrical systems has been determined to not be at fault in this event. The cause of the galling could not be determined. Alarm design contributed to the event in that the operators were unable to determine the immediate location of the ground due to the multiple ground alarms.

4. Manufacturing

No manufacturing flaws have been discovered that could have caused this event. However, faulty welds holding the grounding transformer protection fuse bracket for start up transformer 2-1 contributed to the secondary event, the tripping of the breaker to the main offsite power feeder.

5. Maintenance

Preventive maintenance is not performed on the RCP power connectors, however, lack of such maintenance is not considered to be a contributor to this event. A complicating factor was ineffective housekeeping which allowed micarta type material to be inadvertently left on the resistor banks.

6. Testing

This event was not caused by missed, incomplete, or inadequate testing. A method of checking RCP connectors for high resistance using a heat detection device is being studied. However, access concerns may restrict use of this method.

7. End of Life

None of the failed equipment related to this event was determined to be at end of its normal service life.

8. Inappropriate Equipment Operation

The event investigation team could find no evidence of improper operation of equipment.

IV. Analysis of the Event:

The previously analyzed condition 2 event described in the plant

Final Safety Analysis Report Update for the loss of offsite power and turbine trip bounds this event. Results of the "Complete Loss of Forced Reactor Coolant Flow" analysis show that for a loss of all AC power, no adverse conditions occur in the reactor core. The departure from nucleate boiling ratio is maintained above 1.30. The reactor coolant system is not overpressurized and no water relief will occur through the pressurizer relief or safety valves. Thus, no cladding damage results and, consequently, there is no release of fission products to the reactor coolant system. Since the July 17, 1988 Unit 2 loss of 12 kV startup power event is bounded by this previously analyzed condition, the health and safety of the public were not affected by this event.

V. Corrective Actions:

A. Immediate Corrective Actions

1. The manufacturer of the connector was contacted to determine if a lubricant or antiseizing compound should be used on the connector stud. The manufacturer stated that no lubricant or antiseizing compound was recommended, but a silicon grease could be used.

2. The Neutral Cable for Startup #21 Grounding Resistor was rerouted away from the top of the resistor bank.

3. The Surge Suppressors on the 12 kV Vacuum Breakers were inspected and replaced with new ones.

4. The 12 kV "stress cone" installation procedure was reviewed and determined to be adequate.

5. Affected electrical circuits were checked to insure that no additional damage existed.

B. Corrective Actions to Prevent Recurrence

1. The heat loading that occurs when the grounding resistors are energized will be evaluated.

2. An investigation will be performed to determine if other cables over the start up and auxiliary transformer grounding transformer resistor banks need to be rerouted away from this potential heat source.

3. Changes to the ground alarm system that could eliminate false alarms will be investigated.

4. Training on proper assembly of high voltage "stress cones" connectors will be performed.

5. Signs will be installed on the grounding resistor cages instructing that no material is to be placed on top of the enclosures.

6. An infra-red detection surveillance of the Unit 2 RCP high voltage connectors will be performed after the RCPs are placed in service. In addition, this surveillance will be performed after the RCPs are in operation following maintenance that could affect these connections.

7. The annunciator response manual will be revised to incorporate lessons learned during this event.

8. Additional training will be provided to operators to increase basic knowledge of the high resistance grounded high voltage systems.

VI. Additional Information:

A. Failed Components:

Power Distribution Connector K6500NR
Elastimold Division of AMERACE Corporation

B. Previous LERs on similar events:

None

ATTACHMENT # 1 TO ANO # 8808240244 PAGE: 1 of 1

Pacific Gas and Electric Company 77 Beale Street James D. Shiffer
San Francisco, CA 94106 Vice President
415/973-4684 Nuclear Power
TWX 910-372-6587 Generation

August 16, 1988

PG&E Letter No. DCL-88-205

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Re: Docket No. 50-323, OL-DPR-82
Docket No. 50-275, OL-DPR-80
Diablo Canyon Units 1 and 2
Licensee Event Report 2-88-008-00
Reactor Trip and Subsequent Safety Injection Following an
Electrical Ground on a Connector to Reactor Coolant Pump 2-2
Due to Galling on the Threads of an Aluminum Stud

Gentlemen:

Pursuant to 10 CFR 50.73(a)(2)(iv), PG&E is submitting the enclosed Licensee Event Report (LER) regarding the manual initiation of a reactor trip and a subsequent safety injection. In accordance with Technical Specification 6.9.2 and Action Statement b. of Technical Specification 3.5.2 this report is also being submitted as a Special Report to report the eleventh actuation of the emergency core cooling system that resulted in a discharge of water into the core. In addition, in accordance with Technical Specification 6.9.2 and Action Statement c. of Technical Specification 3.4.9.3, this event is also being submitted as a Special Report to report the use of a pressurizer power operated relief valve (PORV) to mitigate a reactor coolant system pressure transient.

This event has in no way affected the public's health and safety.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

/s/ W. B. KAE
ER/for
J. D. Shiffer

cc: J. B. Martin
M. M. Mendonca
P. P. Narbut
B. Norton
H. Rood
B. H. Vogler
CPUC
Diablo Distribution
INPO

Enclosure

DC2-88-EM-N082

2266S/0063K/DY/2137

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